This Page Is Inserted by IFW Operations and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents will not correct images, please do not report the images to the Image Problem Mailbox.

€1.354

No. 736,288



June 14, 1966 ISSUED CLASS 166-16

CLASSIFICATION

GROUP

CANADIAN PATENT

LINER EXPANDER

Joe C. Stall, Tulsa, Oklahoma, U.S.A.

Granted to Pan American Petroleum Corporation, Tulsa, Oklahoma, U.S.A.

APPLICATION No. 897, 460

PRIORITY DATE

No. OF CLAIMS

LINER EXPANDER

10

20

30

This invention relates to a constant force spring device, and more particularly, to a device for expanding a metallic liner wherein an expanding die is urged against the liner by a constant force spring device.

Heretofore, a method and apparatus have been developed for installing an expanded metallic liner in an oil well or other conduit. Typically, a corrugated steel liner is inserted in a conduit which is to be lined, the greatest peripheral dimension of the liner being slightly less than the inside diameter of the conduit. An expanding tool is passed through the liner placed in the conduit, and a first-stage expanding die causes a gross plastic deformation of the liner, which is expanded outwardly against the inside of the conduit. A second-stage die on the tool then provides an additional finer deformation of the liner to provide a smoother, more finished surface on the inside of the liner and to assure more complete contact between the conduit and the liner. In a typical design of this type expanding tool, the frictional drag of the first-stage die supplies the expanding force for the second-stage die, which expanding force is a direct function of the strength, or wall thickness, of the conduit in which the liner is being installed. For example, in lining oil well casing, heavy wall casing may cause a very high frictional force which results in excessive pressure being required to push the expander through the liner. The application of the great forces required may result in rupture of the casing or in breaking the installing tool. In instances where the internal diameter of the conduit is somewhat less than that anticipated, the resulting forces can cause the tool to become stuck in the casing, or otherwise cause damage to the casing and the tool. In other designs, such as where a cantilever spring arrangement is employed in connection with the secondstage die, various difficulties are encountered in obtaining a spring mechanism having the desired strength in combination with the other spring characteristics, and with the tool dragging against the inside wall of the conduit after being passed through the liner.

Since tools of the type mentioned above often are employed in wells deep in the ground, it is highly preferable that a tool be used which under no circumstances will become stuck in the well or cause damage to the well. Any such trouble occurring in a well can result in considerable loss in time and great expense in making repairs.

An object of the present invention is a device for applying a constant force to an expanding die or other similar apparatus so that a preselected maximum force is exerted against a work piece. Another object is an improved expanding tool for installing metallic liners in a conduit, which expanding tool can apply no greater than a predetermined force to the liner being installed in the conduit. Still another object of the invention is an economical and easily fabricated constant force spring device. A further object is a rugged, easy-to-operate expanding tool employing such a spring device. These and other objects of the invention will become apparent by reference to the following description of the invention.

In accordance with the present invention there is provided a constant force spring device which comprises a body member, an elongated column element adjacent said body member, bearing plate members contacting the two ends of said column at least one of said bearing plate members being longitudinally movable in respect of the other and stop means on said body member to limit the deflection of said column element to prevent permanent deformation of said column element upon the application of a compressive load thereto. In one embodiment of the invention, the foregoing constant force spring device is employed in a tool for expanding a metallic liner inside a conduit, said constant force spring device being positioned on said tool to urge an expanding die member against the liner being installed in the conduit by a substantially constant force.

My invention will be better understood by reference to the following description and the accompanying drawings wherein:

Figures 1A, 1B and 1C, taken together, constitute a partial sectional view of a preferred embodiment of a liner expanding tool according to the present invention; and

Figure 2 is a sectional view of the apparatus of Figure 1A taken at line 2-2; and

Figure 3 is a typical plot of applied Load versus Deflection for the constant force spring device of the invention.

Referring to the drawings, Figure 1A is the bottom portion of a liner expanding tool for use in installing a metallic liner in a well, while Figure 1B illustrates the middle section of such a tool and Figure 1C represents the upper section of the tool. The expanding tool 11 is attached to standard well tubing 12 by coupling 13 and, typically, may be lowered from the surface through a well casing (not shown) to a point in the casing at which it is desired to install a metallic liner. Before inserting the tool into the well, an elongated vertically corrugated liner 14 fabricated from mild steel, or other suitable malleable material, is placed on the tool. The corrugated liner is secured in position by contact at its upper end with a cylindrical shoulder member 16 and, at its lower end by contact with a first-stage expanding die 17 in the form of a truncated circular cone which serves as a firststage expanding die in the manner hereinafter described. The expanding die is fixedly attached to a centrally located, elongated cylindrical hollow shaft 18 which forms a portion of the body of the tool. As shown, the expanding die 17 is held in place between a lower shoulder 19 and collar 21 threaded onto the shaft. A plurality of movable arms 22, preferably provided with outwardly enlarged portions 23 near the top, are disposed in the form of a cylinder around shaft 18. The enlarged portions of the arms 25 upon being moved outwardly contact the liner to perform the final step of expanding the corrugated liner into a substantially cylindrical shape. The arm members 22 are pivotally attached to the shaft so as to be movable outwardly from the shaft by a tapered expanding member 24 slidably positioned on the shaft to serve as a second-stage expander. The surface of the member 24, as shown, moves upwardly along the shaft to engage with the arms and move them outwardly. Advantageously, the inside surfaces of the arms 22 and the outside surface of expanding member 24 form mating sections, typically octagonal in shape. The expansion of the arm members is controlled by the position of the member 24 which moves upwardly

- 3.

until it contacts shoulder 26 provided on the shaft. As member 24 moves in a downwardly direction arms 22 fold inwardly toward the shaft. The expanding arms 22 are held in place on the shaft by collar 27 and circular groove 26 provided on the shaft.

The expanding tool, comprising the first-stage die and the secondstage die is drawn through the liner to expand it in place in the casing. The
first-stage die provides a gross deformation of the liner so that it is
expanded outwardly against the wall of the casing. The second-stage die then
passes through the liner and performs the final expansion to smooth the inner
surface of the liner and to provide more even contact between the liner and
the wall of the casing and effect a fluid-tight seal.

10

20

In operation, the liner setting tool is assembled at the surface, as described above, and a glass cloth saturated with a resinous material may be wrapped around the corrugated tube to form the liner. The assembly is lowered into the well at the location at which the liner is to be set. A liquid, such as oil, is then pumped under pressure down the well tubing and flows through the passageway 29 provided in polished rod 31, through ports 32 and into cylinder 33 connected to the upper end of the shoulder 16. Upon the application of fluid pressure to the cylinder, the piston 34 secured to polished rod 31 moves upwardly in cylinder 33. As shown, rod 36 connects polished rod 31 and shaft 18 upon which is mounted the first-stage expanding die 17. When the piston 34 moves upwardly through the cylinder 33 the expanding die 17 and the secondstage die 22 are drawn upwardly into the corrugated liner 14 and "iron out" the corrugations in the liner, so that the expanded liner may contact the inside wall of the casing in which it is being installed. Positioned on the shaft below the expanding member 24 is a constant force spring member 37 which is employed to urge the expanding member against the expanding arms 22 with a substantially constant force. The force exerted against the arm members being substantially constant, the force transmitted through the arm members to the liner and to the casing will be substantially constant so that either sticking of the tool in the casing or rupture of the casing is precluded. Of course, the force provided by the spring member is preselected so that the frictional

20

30

forces between the tool and the liner and the pressure exerted against the casing are maintained at predetermined safe levels. The constant force spring member assures that the contact pressure between the liner forming portion 25 of the arms 22 is great enough to provide the desired deformation of the casing, while preventing damage to the casing or to the tool.

The constant force spring member 37 is slidably mounted on the shaft 18 and held between the expanding element 24 and a cylindrical lower shoulder member 38 forming a portion of a differential screw element 39 which transmits the losding on spring member 37 to shaft member 18. The differential screw element comprises shaft member 18 on the outside of which are cut male threads 18a, the lower shoulder member 38 provided with female threads 38a and thimble member 41 provided with threads 41a and 41b on the outside and the inside, respectively, to engage with threads on the shaft and the shoulder. The two sets of threads are coarse, such as square, modified square, or Acme threads, to withstand very high loads and differ in pitch so that shoulder 38 is moved upwardly on the shaft 18 when the shaft is revolved relative to thimble 41. The shoulder 38 is secured to the shaft 18 by splines 45 so that it can slide longitudinally, but it is not free to rotate on the shaft. Fixedly attached to the lower end of the thimble is a friction member, such as bow springs 42, a hydraulically actuated friction pad, or other such device for frictionally engaging with the inside wall of the conduit to secure the thimble against rotation with respect to the shaft. Preferably, the direction of the shoulder member threads 38a is the same as that of the shaft threads 18a, e.g. righthand threads, and the pitch, or lead, of threads 18a is slightly greater than that of threads 38s, with the pitch ratio being close to unity. In this manner, clock-wise revolution of the shaft relative to the thimble causes shoulder member 38 to advance upward slightly and a compression load is exerted upwardly on spring element 37 to cause buckling. For example, one satisfactory differential screw was made up using five and one-half threads/inch square threads on a shaft approximately 1.7-inch outside diameter and five and threequarters threads/inch square threads on a shoulder approximately 2.5-inches inside diameter.

Constant force spring element 37 comprises column element 43, advantageously consisting of a plurality of elongated columns disposed around shaft 18. Upper bearing plate member 44 is in contact with the upper ends of the columns and is slidably positioned on shaft 18 to transmit the force of the spring longitudinally against the bottom end of expander member 24. Lower bearing plate member 46 contacts the lower ends of the columns and is moved upwardly along the shaft by longitudinal movement of lower shoulder 38 as a result of revolving differential screw element 39. Grooves 47 are provided in each of the bearing plates, to form an upper race and a lower race, into which the ends of the columns are inserted. These grooves may be shaped to conform with the shape of the column ends if desired. A cover 48 may be employed to exclude foreign matter from the spring mechanism and to protect the spring.

A means for limiting the deflection of the columns is required. Although the column element functions in a buckled condition, application of excessive compressive load thereto would cause total failure or rupture of the columns. Therefore, a pair of stops 49 and 49a are provided for this purpose. As shown, the stops are rigidly connected to the bearing plates, and, in effect comprise upper and lower limiting sleeves positioned on the shaft to slide longitudinally thereon. The ends of the stops may move toward, or away from, each other as the load on the spring member varies. Lower sleeve 49a is prevented from moving down by lower shoulder 38 connected to the shaft 18. However, the spacing between the ends is such as to limit the longitudinal travel of the bearing plate members as they move together to prevent permanent deformation of the column element 43. Various alternative means for preventing damage to the column element may also be employed. For example, pins or rings mounted on the shaft may serve as stops, or the cover 48 provided with suitable connections may be employed for this purpose to limit longitudinal and/or lateral deflection of columns.

The columns of the column element 43 may be arranged around the shaft 18, which as shown here forms a portion of the body of the spring device, with ends of the columns fitted in the races 47. The columns may be

30

- 6 -

fitted closely together as shown, or may be spaced around the race, with separators used between them to maintain the desired spacing. The number of columns employed will depend upon column characteristics and the materials of construction. For exemple, the slenderness ratio of the column may be varied widely, and the column ends may be round, flat, fixed or hinged. The preferred construction is a thin, slender column with rounded ends, free to move within the races shaped to the curvature of the column ends. Materials which may be satisfactorily employed for the columns are carbon and low alloy steels, chromium and nickel-chromium stainless steels, various copper base alloys, such 10 as phosphor bronze, beryllium copper, the high nickel alloys and other similar materials providing satisfactory mechanical properties. Typically, the individual columns are of long rectangular cross-section, with the width being greater than the thickness, and arranged so that the wider face of the columns is normal to the diameter of the shaft. Thus, with sufficient compression loading, the columns buckle, and bend about the axis having the least moment of inertia, e.g., outwardly away from the shaft lo.

For example, a group of columns 0.167-inch thick by 0.438-inch wide by 10.626-inches long, with the ends rounded, were fabricated from A.I.S.I 4340 steel, quenched and drawn at 575°F. Each column was found to require a critical compression loading of 450 pounds in order to buckle the column. After buckling, the columns were found to have a very flat spring characteristic, as shown in Figure 3, wherein P_{c} is the critical buckling load and point C represents the load and deflection at which the stress in the extreme fibers of the column exceed the yield point of the material. Theoretically, the shape of this spring characteristic curve is described by curve QA'ABC. Actually, this curve is described by OABC due to friction in the system. Points A and B represent typical working limits, which, of course, may be varied according to the application for which the spring is designed. For example, where a large number of flexing cycles are not anticipated, a working stress just below the 30 yield point may be used, while with a great number of flexures, the working stress may be held to less than the endurance limit of the material of construction. In the above-mentioned tests, the lateral deflection was limited to

approximately one inch, at which the longitudinal deflection was approximately: 0.225 inches. From zero deflection to the maximum deflection, the 450-pound loading was found to be substantially constant.

In another test a spring device was built, as shown, employing 20 columns, each having a critical buckling load of 1250 pounds. The lateral deflection was limited between 0 and about 1.00 inches by appropriately positioning the stops. Upon compressional loading, the spring element buckled at substantially 25,000 pounds and from a longitudinal deflection of 0.04 inches (buckling) to about 0.15 inches the load remained substantially at 25,000 pounds.

Of course, in designing a spring element as above it is advantageous to obtain the greatest possible value of longitudinal deflection for specified values of lateral deflection and critical buckling load, while maintaining the stress level in the columns at a safe level. The preferred columns, therefore, are laminated, as shown in Figures 1B and 2, with multiple flat members making up each column.

In the operation of the above expanding tool for setting a liner in vell casing, the made-up tool is lowered into the vell as mentioned above, with the arms 22 in the retracted position. When the tool is at the desired level, the well tubing is revolved. The friction member \$2\$ engages with the wall of the casing and prevents thimble \$1\$ from revolving. With several revolutions of the tubing, lower shoulder \$3\$ is moved upwardly by differential screv \$9\$ to buckle spring element \$7\$ which has a predetermined critical buckling load. This load is transmitted upwardly against the lower end of expander \$2\$, and its tapered surface is engaged with the tapered surface on the inside of the arms 22 to urge the arms outwardly with a substantially constant force proportional to the critical buckling load of the spring element. Subsequently, the expanding tool is passed through the liner to expand it in the casing in the manner described hereinbefore.

The foregoing description of a preferred embodiment of my invention has been given for the purpose of exemplification. It will be understood that various modifications in the details of construction will become apparent to

the artisan from the description, and, as such, these fall within the spirit and scope of my invention.

٠ 9 -

I CLAIM:

1

2

3

- 1 1. A device for expanding a metallic liner inside a conduit which 2 device comprises a shaft element, an expanding die member attached to said shaft element, said die member comprising a movable liner-forming member positioned on said shaft and being radially movable in respect thereof to contact said liner, an expander member slidably positioned on said shaft 5 6 between said shaft and said die member to move said liner-forming member from said shaft, and a constant force spring member positioned on said shaft 7 8 to contact said expander member and to maintain said expander member against said liner-forming member, whereby said liner-forming member is urged against 9 said liner by a substantially constant force. 10
- 1 2. In a device for installing an expanded metallic liner in a conduit wherein an expanding die is moved through a liner positioned in said 2 3 conduit to expand said liner: a cylindrical shaft element, an expanding die member attached to said shaft, said die member comprising a plurality of arm 5 members disposed around said shaft and being pivotable outwardly therefrom to 6 contact said liner, a cone member slidably positioned on said shaft between 7 said shaft and said arm members to urge said arm members outwardly from said 8 shaft, and a constant force spring member positioned on said shaft to contact 9 said cone member and to maintain said cone member in contact with said arm 10 members, whereby said arm members are urged outwardly by a substantially \mathbf{n} constant force.
 - 3. The device of Claim 2 wherein said constant force spring member comprises a plurality of columns disposed around said shaft, a first bearing plate member and a second bearing plate member, each of said bearing plate members contacting opposite ends of said columns, at least one of said bearing plate members being movably positioned on said shaft and being in contact with said cone member, stop means connected to said shaft to limit the axial travel of said movable bearing plate member along said shaft, and compression means for maintaining a lateral deflection in said columns.

- 1 4. The device of Claim 3 wherein said compression means comprises
 2 a differential screw connecting said spring member and said shaft.
- 5. The device of Claim 3 wherein said stop means comprises a

 Sleeve-like element connected to said movable bearing plate member and

 slidably positioned on said shaft and a member connected to said shaft to

 limit the travel of said sleeve-like element.
- 6. The device of Claim 3 wherein said columns have a rectangular cross-section, the width being greater than the thickness, and having the didnet face normal to the diameter of said shaft.
- 1 7. A device for installing an expanded metallic liner in a conduit 2 Which comprises a cylindrical shaft element; an expanding die member mounted on said shaft, said die member comprising a plurality of arm members disposed circumferentially around the outside of said shaft and being pivotable out-5 wardly therefrom to contact the liner; a conical expanding member slidably 6 positioned on said shaft between said shaft and said arm members to urge said arm members outwardly from said shaft; a plurality of slender columns, each 7 8 having a long rectangular cross-section and disposed circumferentially about 9 said shaft; an upper bearing plate member and a lower bearing plate member, 10 each slidably positioned on said shaft and contacting opposite ends of said 11 columns; limiting sleeves attached to each of said bearing plate members 12 and slidably positioned on said shaft; a shoulder member on said shaft; a 13 differential screw element connecting said shoulder and said shaft to apply 14 a buckling load to said columns; said shoulder being engageable with the 15 limiting sleeve connected to said lower bearing plate member, whereby the 16 axial travel of said bearing plate members is limited; said column members 17 transmitting their buckling load to said arm members to urge said arm members 18 outwardly with a substantially constant force.

NO 1.5 Ment

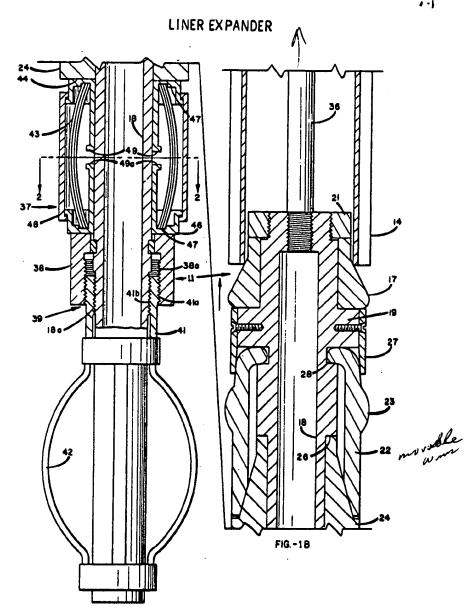
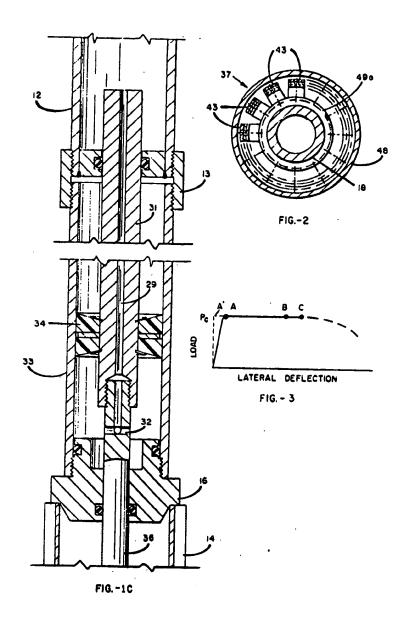


FIG. -1A



,

Sorry, the requested images for patent number 736288 are unavailable.

O Her Majesty the Queen in Right of Canada, 1999

Canada http://strategis.ic.gc.ca 00736288cim.afp Page 1 Page 1



786288

I CLÁDI:

2. A dorice for expending a metallic line; hunds a conduct which device comprises a shaft almost, on expending the number observational to make their closume, stid die number comprising a movable liner-forming member positionel on said shaft and being ordially moveble in respect thereof to contact mid liner, as expender moster aliably positioned on said shaft between said shaft ones said die number to move said liner-forming member from said shaft, and a constant force spring member positioned on said start to contact said sayments sucher against the contact said sayments sucher and to saintain said expenses seether against said liner-forming member, whereby said liner-forming member is served against

2. In a device for installing as expended metallic liner in a conduct wherein as expending the is moved through a liner positioned in sale sombies to expend mail liner: a cylindrical short almost, as expending the somber attached to said about, said the newbor comprising a plurality of are numbers disposed around said short and tong phystolic unbeautity therefrom to notice said liner, a come number allicably positioned on said short between said short and said and masters to very said arm numbers coinsietly from said short, and a commant force opping number positioned on only staff to contest said once number in contact with said are numbers, phenety said ten tentures are urged outwardly by a substantially constant force.

3. The ferrios of Claim 2 shareds said accretant force speing contercomprises a planality of economic hispones around which sharing plate member and a second hearing plate member, each of said bearing plate members conducting opposite only of said columns, at least one of said bearing plate members being movehly positioned on said which was being in contact with said come member, stop means connected to said which to limit the actual trival of said movehly bearing plate number along said shart, and compression means for maintaining a lateral desiretion in said columns.

B

10



00736288clm.afp Page 2 Page 1 of 1



736288

- . 4. The device of Claim 3 wherein ends compression grows comprises a difformedial survey consecuting main apring number and said shaft.
- 5. The device of Chaim 3 wherein anid shop means comprises a slave-like element connected to said would bearing plate member and midably goal blooms on said shart and a scaler consequent to enid shart to limit the travel of enid also vehille element.
- 6. The device of thate 3 wherein said columns have a machingular trans-station, the width being greater than the Michigan, and having the wider fury ground to the dissector of each shaft.
- 7. A device for installing on expended estallis liner to a co class a extinction sheft oliment; on expending the number manufed on said shall, said die sembar sumpristing a plantity of are sombare dispose formatically around the outside of each shaft and budge prescribe outmonth therefrom to opposed the liner; a scalest asymmton master sithably him agus or excellent was birm bot thats birse counted these birse so be re censionly from said shafts a planelity of elemen columns, cash baving a long rectangular occas-section and disposed streambinentially shout still an upper bearing plate master and a lover tearing plate stater, such shidelily positioned on said mark and contacting apposite ands of said ni limiting alsores uttended to each of said bearing plate members and alidably positioned on sold statts a shoulder smalet on sond abailts a differential acres element emmerting will shoulder and said short to apply a lumbiling look to mid enimons suid thouless being emphasible with the limiting siners semmented to each lower bearing plate member, whereby the ariel treval of mid bearing plate numbers is limited; mid column ventors transmitting their bushing losd to exid are numbers to urgs said and spen establic with a substantially constant force.

A

13





LITER EXPLICIT

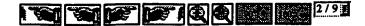
This invoices explains to a constant force syring device, and nore particularly, to a device for explaining a matallic liner wherein an expension die in organ against the limps by a sprease loss against device.

Becometions, a sattoot and apparettes have born developed for installing on expensed scinition times in on cell well or other constall, typically, a morraphical clock liner is immarted in a scodelic which is in he hiers, the greatest purishment-dissection of the lines being eligibily less then the limite discrete of the estable. In separating tool is persent timer placed in the centuit, and a first-stone expansion die atis deformation of the liner, which is assemied extracelly the inside of the conducts. A mesond-stage die on the took then ridge as additional firmy deformation of the limpy to provide a smooth or the incide of the lines and to water come complete between the conduct and the liner. In a typical design of this type sing tool, the frictional drug of the first-sings dis sugains the ting force for the second-stage dio, thick expending force is a kineat function of the strength, or wall thickness, of the conduit in which the or is being installed. For example, in limits oil well curing, beary wall easing may some a very high trintional force which results in exs boding pagedred to push the expender through the limer. The application of the great forces required any result is report of the earing brearing the implaiting tool. In tasteness there the interval. e of the conducts to exercise them that exclusively, the resultpe the tech to become stank in the century, or otherwise age to the ensing and the book. Its other draigas, such as there a quatilever spring arrangement in employed in exmention with the secondstign dis, various difficulties are encountered in obtaining a spring rechnetes having the derived strength is continuities with the other springstraightion, and with the took drugging against the incide will of the th after bring passed through the lime.

·A

*





fince tools of the type manifound above of the are employed in welldeep in the growd, it is highly preferable that a tool be used which under no circumstances will become stack in the well or unuse damage to the well. Any such trouble coccurring in a well one remail in considerable tops in time and creat consess in making repairs.

As abject of the present invention is a device for applying a constant three to an expending die at other similar appearing so that a preequation maximum fuses to anarthe against a work place. Another shipes is an
improved expending tool for installing metallic liners in a sandat, which
expending tool can apply so greates then a predeterminal force to the liner
being installed in the constant. Still another object of the invention is an
economical and enally fabricated expending force spring device. A further
chiech is a regard, anny-to-oversic expending tool contaging such a spring
device. These and other objects of the invention will become apparent by
reference to the following description of the invention.

In consultance with the present terminan there is provided a conciout force spring device which comprises a body member, an elongated solumn element adjacents and body member, bearing plate numbers contecting the two reads of anid column at least one of ends bearing plate numbers being longitudinally accepts in respect of the other and stop means on anid body mimber to list? the destination of each solumn element to provint parametric deformatings of ends solumn element upon the application of a compressive loss theoreto. In one exhestimant of the investion, the foregoing essential three expring device to explored in a tool for separating a artialite lines inside a ministic mili constant force speciag device being partitioned as each tool to wrom an expending the member against the lines being invisited in the conduct by a substantially constant force.

by investion will be befor understood by reference to the following description and the eccumulating drawings wherein:

Pigero 14, 18 and 10, taken together, conviltute a portion setional view of a protected embediesco of a liner expending tool assembles to the present inventions and

n in teameration, on statemen



Page 1 of 1



736288

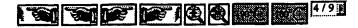
Figure 2 to a sectional view of the apparatus of Figure 1A tabus at

Figure 5 is a typical plot of applied lost versus definction for the constant force spring device of the invention.

Inferring to the Averings, Pipers 14 is the bottom portion of a liner expending tool for one in installing a metallic liner to a well, while Figure 19 Libertrotes the stable section of such a took and Figure 10 topsesents the upper sertion of the tool. The expending tool il is attached to standard well taking if by accepting 15 ond, topically, may to looped from the stattes through a well ensing (not shown) to a point in the source at which it is secured to implait a metallic liner. Before inserting the took into the well, as alongsted vertically correspond timer th fabricated from mild steel, or other suitable mileshie meterial, is placed on the tool. The correspond liner is seement in position by eartest at its upper end with a cylindrical ther 16 and, so the lover end by context with a first-stage espanding dis 17 in the form of a proposted circular some which serves as a firstmeeting die in the opener bereinstier described. The expending die is firmly abtended to a controlly located, elemented cylintrical believ short lot is held in place between a lower shoulder 19 and collar 21 threaded outo the short. A plurality or morphic eros 25, precently provided with outserelly calarge's portions 25 sear the top; are disposed in the form of a equipher d shaft 18. The enlarged portions of the erro 23 eyes being soved outof the liner to perform the final step of expending the surregular. .. or into a substantially sylicarized shape. The ere seaters III are pivotelly of to the staff so as to be moveble originally from the shaff by a tapared expending number 26 alidably positioned on the sheft to corve on a second-stage appender. The surface of the member 20, as shown, moves specially along the start to sagage with the eras and move them outpurally. Advantageously, the see of the erse 22 and the outside surface of expending mesher 25 enting sestions, typically categoral is shape. The expension of the arm



AND THE PROPERTY OF THE PROPER



wrill it contents ebuilder 26 provided on the chaft. As number 25 worse in a documently direction eras 62 fall invertily toward the shaft. The expending arms 22 are bulk in place on the shaft by collect 27 and circular grooms 20

The expending tool, comprising the first-stage die end the secondstage die is dress through the liner to expend to us piece in the contage. Due first-stage die prevides a gross deformation of the liner so that it is expended outwerfly against the well of the sening. The second-stage die these passes through the liner and performs the final expenden to smooth the inner secretor of the liner and to provide more even contact between the liner and the well of the coming and effect a finid-light seal.

In operation, the liner setting tool is smoothled at the surface, so described shore, and a glass thoth saturated with a rectnoss material may be at the corrugated tobe to form the liner. The assembly is lovered into the wall at the leastion at which the liner is to be set. A Liquid, such so oil, is then people under presence down the well tubing sed flows through way 29 provided in polished not 51, through purts 52 and into egilssted to the upper soil of the shoulder 16. Upon the application of fluid promume to the oplinder, the piston 34 second to polished sod 51 moves operally in spinster 33. As shows, rot 36 commerce polished rot 31 and shaft 18 spot sideh is nessied the First-riege expending die 17. Then the piston % rily through the splinter 35 the expending die 17 and the secondstage die 22 ero droms upwerdly into the engraphed liner in and "iron out" pations to the liner, so that the expended liner may contact the tunide well of the ceaing in which it is being installed. Porisioned to the shall below the expending menter th is a comment tures syring number 37 which is employed to true the expending number against the explaining some 22 with a substantially constant force. The force exacted equinst the are maddle battag betweethelly constant, the force transmitted through the arm m liner and to the during vill be embetantially accordant so that either sticking of the tool in the centag or repture of the cardeg is precluded. Of course, the three provides by the opring member is preselected so that the frictional

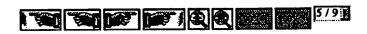


CONTRACTOR OF CONTRACTOR OF THE CONTRACTOR OF TH



forces between the tool and the liner and the pressure exerted definet the one ing are emintalized at predatarisinal safe levels. The complete force spring maker assures that the contact pressure between the liner forming portion 20 of the sons 22 is great enough to provide the Sorinal deformation of the samture, while presenting demons to the coning or to the tool.

The equators force spring sensor 77 is alignity mounted on the above 18 and but have the expecting alongst 20 and a sylintrical lower shoulder master 36 forcing a portion of a differential server alongst 39 which between the localing on spring number 37 to short master 16. The differential surver alongst comprises that's under 16 as the certain of which are one as in terms like, the lower member 30 provided with freezie threats 35s and threats and the lands, number \$1, provided with threats \$1s and \$1b on the extends and the lands, respectively, to unque with threats \$1s and \$1b on the extends and the lands, respectively, to unque with threats as square, scrifffed square, or fame threats, to without any high lands and differ in prich so that mouther 35 is sound squarely on the shart 16 when the shart is revolved relative to thinkle \$1. The challes of its securet to the shart 16 to splines \$5 so that it can slide langitudinally, but it is not tree to rotate on the shart. Finally armohed to the lower end of the thinkle is a friction scalar, such as how thrings \$2, a hydramically estuated friction pass, or other such device for friedically magazing with the issues as all of the amplifit to occurs the thinkle is an incident to state the threshed \$1s, e.g. right-heat threads \$2s, is the same as that of the shart threads 16s, e.g. right-heat threads \$2s, with the pitch, or land, or threads 16s to shiftly greater than that or intreads \$5s, with the pitch, or land, or threads 16s to satisfy greater than these or interest \$1s, with the pitch relie being alone to unity. It this assumes, clock-wise revolution of the shart relative to the thinkle summes threads \$2s, with the pitch, or land, or threads 16s to satisfy greater than the shart approximately 1.7-inch outside dissector and five and threads threads/isch aquare threads on a shart approximately 1.7-inch outside dissector and five and threads.



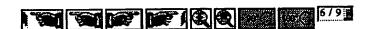


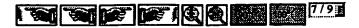
Donatest force spring element 37 comprises solden element 43, structures and secondly security of a planelity of alongsted solumes disposed around shorts 15. Upper bearing plate number 14 is in contact with the diper ands of the solume and to elimbly positioned on shart 15 to treatest the force of the spring longitudinally against the bottom and of expenden seator 54. Lower bearing plate number 16 confects the lover made of the columns and 18 moved sparsely along the satisfy lengthelian movement of locar satisfies 30 on a result of revelving differential server almost 39. Greenes 37 are provided in seat of the bearing plates, to form an upper race and a lover race, into which the coals of the columns are inserted. These grooves my in chapet to contarn with the shape of the column such if desired. A cover 18 may be employed to amolade foreign antier from the spring mechanism seak to protect the covers.

A mean for limiting the deflection of the columns to required.

Atthough the column element functions in a buckled constitute, application of crossedive accurrently load thereto would sense total failure or repture of the columns. Therefore, a pair of stops by each the new provided for this purpose. In shore, the stops are rigidly commanded to the burring plates, and, in effort comprise upper and loans limiting alasmas positioned on the shaft to alide longitudinally thereon. The under of the stops may some lowest, or many from, each other so the load on the spring number vertex. Lower slaves by a prevented from nothing dama by lower shoulder 36 accurated to the chart 16. However, the spacing between the ands in much as to limit the longitudinal traval of the bearing plate numbers as may move together to prevent permanent deformation of the solumn alasmats by. Turious alternative manss for preventing stange to the solumn alasmats may also be employed. For example, plus or rings accurate on the chart may serve as atops, or the cover 48 provides with switched counterland of columns.

The columns of the calman eigenet h) may be extraged exceed the chart lot, which as shown here turns a partion of the body of the spring derive, with make of the columns fithed in the recen by. The solumns may be





ritted closely together as abore, or way he spaced around the race, with represented used between these to maintain the desired spacing. The results of combinates ampliqued will depart upon colours abundualistics and the emission of combination. For example, the elements ratio of the column may be varied withinly, and the column made say be round, flat, flavoi or hasped. The preferred construction is a thin, element column with resemble ands, from to now within the races shaped to the convenient of the solumn ends. Materials which may be estimiserably employed for the solumn are on and low alloy steads, chronica and michal-elements stabless stockers and low alloy steads, or passagher because, benyillin support, the high michal allows and other similar materials providing actisfactory suchesiani properties. Typically, the individual column are of long restamplies cross-cention, with the midth bring positor than the latchmass, and accomplish cross-cention, with the midth be computed in anomal to the numerator the short. Thus, with surfacient conspection loading, the columns backle, and band about the minimal having the loars somest of inertia, e.g., outeratily says from the short 15.

For exemple, a group of columns D.167-inch thick by 0.838-inch wide by 10.626-inches long, with the ends rounded, were fabricated from A.f.S.I him obsert, question and direct at 77572. Buth column was found to require a critical supersuming lowling of 550 pounds in prior to bunkle the entume. After bunkling, the entume were found to have a very flat spring characteristic of represents the lond and deflection at which the alress in the extense fibers of the deliver exceed the yield point of the untertal. Encounterally, the chape of this againg characteristic surve is described by corve 04/MD. Actually, this curve is described by 0430 due to friction in the system. Potota A me is represent typical vorting limits, which, of course, may be varied according to the application for which the spring is designed. For example, where a large master of floring system we not subliqueted, a working stress just below the yield point may be used, while with a great master of florines, the working stress may be held to less than the enforces that of the antertal of constraints on the above-marrisons heats, the lateral inflortion was limited to



Spyronimently one inch, at which the longitudinal deflortion was approximately 0.887 inches. From more defination to the assistem deflortion, the \$50-pound loading was found to be submissibily constant.

In emother test a spring device was built, as sheen, employing 80 columns, each having a critical bushling load of 1250 younds. The internal definition was limited between 0 and about 1.00 inches by empropriately positioning the stope. Once compressional loading, the spring element bucklet wit enhancially 25,000 pounds and from a long-tokical defication of 0.0% inches (making) to stook 0.15 inches the load reasonal substantially at 85,000 pounds.

Of source, in conjusting a spring element on above it is advantagement to obtain the greatest possible value of longitudinal defluction for specified values of laboral defluction and critical bupiling load, while uninterlaing the attest level to the columns at a safe level. The gratured columns, therefore, are laminated, as shown in Figures 12 and 2, with exitiple flat employs unless on another columns.

In the operation of the above capaciting tool for switing a liner in wall encing, the auto-up tool is lowered into the well as mentioned above, with the area 22 in the retreated position. Shen the tool is at the desired level, the scale totaling is revealed. The friction number by capace with the wall of the making and prevents thinkle 41 from revolving. With several revolutions of the twing, lower absolute 35 is moved agreeming by differential server 39 to bushle spring almost 37 which has a predeferminal critical bushling load. Shis land in transmitted agreedly against the lower and of acquaiter 26, and its theorem surface is capacity with the taperal surface on the incide of the oras 21 to argue the lane caterally with the taperal surface constant force proportional to the critical bushling load of the spring almost. Subsequently, the expending tool is passed through the lines to expend it is the caping in the sector described by also core.

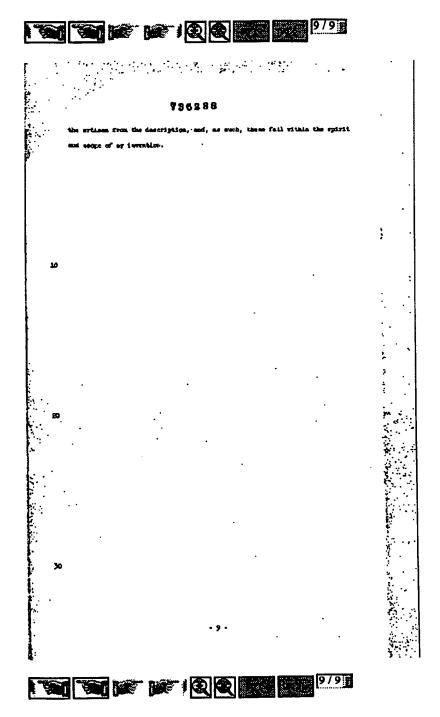
The foregoing description of a preferred embeliance of my investion.

Les best given for the purpose of examplification. It will be understood that
regions medifications in the detects of association will become apparent to

- 0 -

CAN IN THE RESIDENCE OF THE PROPERTY OF THE PR

8/9





(Vinit

